in the latter case biologists will be compelled, by pressure from outside, especially from the followers of other sciences, to adopt the right methods, whatever they may be. But I am concerned with mind and education, and the moment one tries to reach bed-rock in such matters one finds oneself in biological quicksands. One is told that some characters are innate and some acquired, but not the distinction between the innate and the acquired. It is understood that things that are learned are acquired, but apparently no one has tried to ascertain how much is learned or how it is learned. Seemingly, all biologists are agreed that, in themselves, acquired characters are trifling things ; but while Lamarckians think them important through their cumulative effects, neo-Darwinians, conceiving them as transient, think them unworthy of study. Both parties mean one thing when they apply the word " inherit " to " innate " characters, and the exact opposite when they apply it to " acquirements."

Man is the educable animal, say some biologists. He is not educable, say (in effect) others who declare that in his mental make-up nature is four, perhaps nine, times more potent than nurture. One admires the precision of statement, but wonders what is meant. As I understand it, man's nature is such that he is particularly responsive to the nurture of mental use. It is as if a physicist had stated that the steam is four, perhaps nine, times more potent than the engine. And so on. Meanwhile, prejudice controls education and society flows towards the cataracts. I may be very ignorant as to facts and mistaken in my opinions, but in that case my demolition should be a holiday task to the trained and learned intellect. Failing demolition, I cannot help believing that biologists do not realise how very great their science is, or might be, and how vitally and immediately important their labours are, or should be. Incidentally, I have sought in these letters of mine to indicate the high importance, as it appears to me, of classifying characters, not as innate and acquired, but, as physiologists do, according to the stimuli which cause them to develop. So far as I am able to judge, unless scientific men ascertain precisely how mental characters are developed, and then vigorously apply their knowledge for the betterment of education, modern society will soon be on the rocks.

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## Configurations of Molecules of Benzenoid Substances.

Prof. Robinson's remarks (Nature, April 15, p. 476) on Sir William Bragg's representation of the naphthalene molecule, as it occurs in crystals, lead me to invite attention to results obtained recently by Mr. G. H. Christie and myself. In a paper which will be published in the forthcoming number of the Journal of the Chemical Society, the resolution of *trans*-6 : 6′-dinitro-diphenic acid into optically active components is described. This, with the fact that an apparently homogeneous brucine salt has been obtained from the *cis*-form of the acid, indicates that in the separate molecules (as distinguished from their crystalline aggregates, to which Sir William Bragg's results apply) of these compounds the two benzene nuclei are not coplanar.

If this be so, it follows that the direction of the valency of each of the carbon atoms through which these nuclei are united is not, as represented in the usual formulæ for benzene, exerted in the plane of the benzene ring, and further, that this condition is a stable one rather than a phase of an oscillation of the type referred to by Prof. Robinson. It may be possible to determine to what extent, if at all, this stability involves a modification of the normal benzenoid properties associated with two benzene nuclei. Differences between diphenyl itself and benzene in respect of their molecular refraction, and behaviour on catalytic reduction and towards ozone, are already on record, so that it will also be pertinent to inquire whether the fixity of configuration is a general property of diphenyl derivatives, or is dependent on the nature of the substituents present, and connected, for example, with the observations of Baly and Collie (Trans. Chem. Soc., 1905, 1339) on the modification of the ultra-violet absorption of benzene by the introduction of a nitro group.

In any case, our result would appear to supply the first direct experimental proof that other configurations of the separate benzene molecule may exist than the plane (Kekulé) type. For the great majority of chemists, who also recognise the merits of the Kekulé formula, or some modification of it, this will involve the acceptance of some dynamic conception, such as, for example, has been advocated by Collie and by Bloch. It will be noted that one phase of Bloch's formula corresponds closely to that deduced by Sir William Bragg from his observations on the diamond and on naphthalene and its derivatives.

It should perhaps be pointed out that the above suggestions depend for their validity on the assumption that the relationship between the isomerides is stereochemical in the ordinary sense. There is always a possibility, which, however, will perhaps be generally considered remote, that the difference may be rather one of structure, in that the two compounds contain, for example, different types of nuclei.

J. Kenner.

The University, Sheffield, April 21, 1922.

## The Speed of Light.

In a discussion in Nature last year (March 10, vol. 107, p. 42) Majorana's experiment was cited as direct proof that the velocity of light is independent of the motion of the source. In reality, however, there is a disadvantage in his method which seems to the writer very greatly to lessen the value of his results.

Majorana measured the wave-length of the green light from a moving mercury-vapour tube by means of a Michelson interferometer, and detected the change of wave-length that is required by the usual Doppler theory (*Phil. Mag.*, 37, p. 145, 1919). Now it is easily seen that the frequency of the waves arriving at the receiving apparatus will undergo the usual Doppler change whether the speed of propagation is altered (moderately) or not, and speed equals wave-length times frequency, hence Majorana concludes that the speed of the light from his tube was the same when the tube was moving as when it was at rest. But obviously he measured the wave-length only after the light had suffered one or two reflections or transmissions in stationary apparatus, and its velocity might easily have been altered by these processes. Any conclusion from his results must therefore rest, at best, upon very indirect reasoning.

We may freely admit that a satisfactory emission theory consistent with all the facts that are known to-day, including Majorana's result, would be difficult to construct. Yet it does seem regrettable that we have still no simple direct proof of the second postulate of Relativity.

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Perhaps the simplest way to test the postulate directly would be to observe the Doppler effect with a concave reflecting grating so set as to form the image on the normal to the surface of the grating (cf. Tolman, *Phys. Rev.*, 35, p. 136, 1912); the retardation then occurs entirely before reflection, and it is the wave-length of incident light which is measured by the deviation. Any uncertainty as to the relative speed of the reflected rays can be removed by making the line of motion of the source pass through the centre of the grating, and then observing the effect of the motion upon the position of the central image when the grating is turned so as to bring this image into the position formerly occupied by the diffracted one. In these circumstances, for reasons of symmetry the speed of the incident waves along two rays equally inclined to the direction of motion must be the same; if it then turns out that the position of the central image is unaffected by the motion, it will follow that the speed must likewise be the same along the two corresponding reflected rays. This conclusion will hold also for the two diffracted rays which take these paths in the main experiment.

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## On the N-Series in X-Ray Spectra.

With the new and very powerful X-ray-spectroscopic outfit constructed by Prof. M. Siegbahn (described in *Comptes rendus*, 1921, p. 1350) I have endeavoured to find a weaker group of lines in the X-ray region than the lines previously known as M-group. I have been able to find some lines which most probably must be referred to the N-series of the elements uranium and thorium. Hitherto, the measured wave-lengths for these lines lie for uranium between 8·6-12·0 A.U. and for thorium between 9·4-13·5 A.U.

From the theoretical and experimental work done by Coster and others, we are able to estimate the wave-lengths of the lines in the N-series. For the elements uranium and thorium we really find that some of these lines must have wave-lengths of about the measured value. For bismuth, however, and the elements in its neighbourhood, all the N-lines must have a wave-length of more than 13 A.U. so that in the present state of spectroscopy it will be very difficult to measure the wave-lengths for these elements.

I am continuing these researches.

V. Dolejšek.

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Lund, March 31.

## A Proposed Laboratory Test of the Theory of Relativity.

With the present interest so strong in devising experiments to test the theory of relativity, it may not be amiss to suggest the possibility of yet another method. According to recent hypotheses, it seems that the stars are the factories producing complex elements from simpler structures. Inside the stars, hydrogen atoms may unite to form helium, and with hydrogen and helium as intermediates, the more complicated atoms may be built. As pointed out by Harkins, Eddington, Perrin, and others, the synthesis of an atom of helium from four hydrogen atoms necessitates the loss of 0·774 per cent. of the mass of the hydrogen atoms. Since we cannot conceive of mass being annihilated, the only obvious solution is to say that mass is electromagnetic in origin and that, in the helium nucleus, the four protons are brought so near to the two electrons that their fields overlap and neutralise each other to some extent, accompanied by a loss of mass. According to the theory of relativity, 1 gram of matter is equivalent to $9\times10^{20}$ ergs or $2{\cdot}1\times10^{13}$ calories. Both Harkins and Perrin have calculated the amount of heat that must be produced by the transformation of four gram atoms of hydrogen into one gram atom of helium. It has the enormous value of $0{\cdot}0078\times2{\cdot}1\times10^{13}$ or $1{\cdot}6\times10^{11}$ calories.

It may be possible for several helium nuclei to unite to form heavier nuclei, such as oxygen for example, without such a great evolution of heat. More accurate determinations of the atomic weights of the so-called "pure" elements would be necessary before we could say much concerning the energy relations in such sub-atomic reactions.

When the nuclei become so large that they are unstable, then the process of synthesis in the stars would stop. But there might be an over-shooting of the mark. With the enormous amount of energy free in the interior of the stars, some of this energy might be absorbed, according to the theorem of Le Chatelier, in the formation of nuclei which would be unstable in an environment not containing so much energy. Energy would be considered as one of the terms in a mass law equation, to use a well-known chemical analogy. The result would be the radioactive elements—uranium, thorium, etc.

Now let us calculate with the aid of the above equation, derived from the theory of relativity, the effect on the mass of a radioactive substance that would be caused by this addition of energy. Rutherford, in his book "Radioactive Substances and their Radiations," p. 582, states that 1 gram of radium in disintegrating to lead gives off $3{\cdot}7\times10^{9}$ calories. If 1 gram of mass $= 9\times10^{20}$ ergs $= 2{\cdot}1\times10^{13}$ calories, then 1 gram of radium in disintegrating to lead would give off 0·00017 gram and 1 gram atom of radium, 0·038 gram in the form of energy. If the atomic weight of RaG (radium-lead) is taken as 206 exactly, then the atomic weight of its parent, radium, may be calculated as follows:

| | | |
|---|---|---|
| 1 gram atom of RaG . . . | 206·000 | grams |
| 5 gram atoms of He . . . | 20·000 | ,, |
| 4 gram electrons . . . . | 0·0005 | ,, |
| $3{\cdot}7\times10^{9}$ calories . . . . | 0·038 | ,, |
| | 226·038 | ,, |

Therefore the atomic weight of radium should be 226·038. Calculations of this type for radioactive substances have been made by Harkins, but he does not state that they may be applied as a test of the theory of relativity.

This calculation involves six assumptions: (1) that the weight of one gram atom of RaG is 206·000, (2) that the atomic weight of He is 4·000, (3) that the weight of 4 gram electrons does not exceed 0·0005 by any great extent when incorporated in the nucleus of Ra, (4) that the amount of energy given off in the disintegration of Ra is substantially that calculated by Rutherford (a 20 per cent. decrease in the value given by him would not change the value for energy in grams in the second decimal place), (5) that the relativity equation connecting mass and energy holds, and (6) that the energy given off in radioactive disintegrations is derived from the atoms themselves and not photochemically from Perrin's hypothetical radiations of extremely short wave lengths. In trying to verify the results of such an equation, there are two more assumptions necessary: that the atomic weights of RaG and of Ra are determined for the pure substances, that there are no contaminating isotopes.

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